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STATUS REPORT 16

Contract No. N9onr-35801  
Project No. NR031-364

For January, February and March, 1953

Signed by:

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Copy No. 5

File No. 544

Mine Safety Appliances Company  
Callery, Pa.

April 15, 1953

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**STATUS REPORT 16**

**For January, February and March, 1953**

**Contract No. W9onr-85801**  
**Project No. NRO31-364**

This report is a brief description of the status of the work on liquid metals for the months of January, February and March, 1953. Technical Reports will be submitted from time to time to cover significant phases or accomplishments in the program.

The outline for this report has been changed in comparison with previous reports in order to group similar experiments, thus giving a better arrangement to the report so it may be more useful.

**I 1000 KW HEAT TRANSFER UNIT**

The above titled "Task" calls for the design, construction and operation of liquid metal loops to deal with a high temperature heat transfer system of 1000 KW energy transfer capacity within the temperature range of 1000°F to 1350°F. Such an investigation, when completed, would result in benefits to suppliers who design and construct equipment for a higher temperature and longer life specifications than hitherto required, an increase in the technology of handling liquid metals at higher temperature and an increase in the personnel available to design and operate high temperature liquid metal systems.

In order to carry out this task order with a fair degree of "over specification" the following loop design specifications were chosen.

1. A NaK loop operating between a temperature range of 1500-1150°F will transfer heat from an oil or gas flame to a Na system through suitable heat exchangers.
2. A Na loop operating between a temperature range of 1400-1100°F will transfer the heat absorbed from the NaK loop to an air sink until all components had been tested at specified temperatures, pressures, etc.
3. The air sink will be replaced with a water-steam loop operating with 100°F feed water and producing steam in the range of 500 psi to 1200 psi with superheat temperatures varying from 650 to 1000°F.
4. Capable pumps and suitable instruments, valves, etc. will be provided for a good test.

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Progress on this task has proceeded to the point where most of the main items have been received and erection is taking place. The rest of this section deals with the present status and progress during the last three months.

**A. Design**

1. Piping. Piping design has been completed for the air cooled system. This design includes stress analysis, pipe pre-heating, leak detection, thermal insulation and pipe supports.
2. Installation. Installation specifications were written for the NaK heater, intermediate heat exchanger, sodium cooler, NaK pump, sodium pump, flow meters and expansion tanks.
3. Water System. The flow sheet for the water system was fixed and some specifications were written for components.
4. Instruments. Specifications were written for instruments for both the air cooled and water cooled systems.
- 5. Miscellaneous. Cold traps, sludge meters and a liquid metal sampling system were designed.

**B. Engineering**

1. Piping. With the completion of the stress analysis, all equipment locations are now firm; piping design and drawings are complete.
2. Foundations. Foundation drawings for all equipment are under way.
3. Piping Support. Supports for suspended equipment and for piping have been designed, ordered and detail drawings are being completed.
4. Specifications. Procurement specifications have been completed.

**C. Procurement**

1. Test Cell. Construction completed as previously reported.
2. Pump and Generator
  - a. Westinghouse Pump. Delivery of this equipment was made on March 26, 1953. Manufacturer performed leak testing

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by mass spectrometer method with satisfactory results. This unit has been set in position in the test cell.

- b. Homopolar Generator. Performance tests are now being run by the manufacturer. Delivery should be made by April 10, 1953.
3. Fin Cooler. This unit was delivered February 19, 1953. Leak testing proved it to be satisfactory. The unit has been erected in position in the test cell.
4. Intermediate Exchanger (Straight Tube Type). This equipment has been delivered, tested for leaks, and found to be satisfactory (as previously reported).
5. Intermediate Exchanger (Hockey Stick Type). Delivery is promised for August 1953.
6. Heater. Seamless tubing has been delivered to the manufacturer and the unit is under construction. Shipment is promised before April 30, 1953.
7. Valves. The first piston operated type valve was delivered on March 3, 1953. It has been leak tested and found to be satisfactory. The second valve is now under construction. Delivery is expected before April 30, 1953.
8. Check Valves. The three check valves were delivered on March 2, 1953. Leak testing has been completed and has proven the units satisfactory in this respect.
9. Mechanical Pump. This pump is now in the shop. Delivery is scheduled for the end of May, 1953.
10. Steam Generator and Superheater. Final drawing revisions are now being made and a quotation being prepared with materials now being procured.
11. Steam Condenser and Cooler. Purchase order is being prepared. Delivery is promised along with Steam Generator.
12. Instruments. All indicating, recording and control instruments, and necessary accessories have been ordered. Delivery of some instruments has already been made. Control instruments, panels, and accessories for the heater have been received.

Control instruments, panels and operating switch gear for the homopolar generator and the electromagnetic pump will be delivered with the equipment.

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13. System Components. Charge and expansion tanks, cold traps, and cover gas purification are all under construction.

Piping, fitting, insulation and heaters are on hand.

**D. Construction**

1. Piping. Erection of piping is proceeding satisfactorily.
2. Sodium Loop. All major equipment for the sodium loop is now on hand and construction has begun.
3. NaK Loop. Construction of the NaK loop will begin after completion of the sodium loop construction. Final completion of the NaK loop is dependent on arrival of the heater.
4. Gas Supply. A 4-inch gas line has been laid to provide sufficient natural gas for the heater.
5. Electrical Power. Contracts have been let to make additional electric power available at the test cell. It is expected that this work will be completed about May 8, 1953.
6. Stand-By Power. A foundation and shelter for stand-by power generators is now under construction. Expected date of completion is April 12, 1953.

**E. Testing**

1. Allis-Chalmers' Pump. Allis-Chalmers' 1A pump was installed in a test loop and performance tests run at the 1000 KW NaK conditions. The pump was operated successfully at 130 GPM while delivering 28 lb./sq.in. total dynamic head at temperatures to 1150°F. The pump efficiency at these conditions was 11.4% (this efficiency should be increased by using a drive motor of proper size).
2. Hydraulic Pressure Losses. A water loop was constructed to measure pressure drop through various piping geometries and through the components. Pressure drop measurements were made through the Griscom-Russell intermediate heat exchanger, the Lunkenheimer valve and several piping assemblies.
3. Welding. Sample welds in type 316 stainless steel pipe were made to Navy specifications and examined. X-ray examination of these welds has been completed and samples are now being examined for metallurgical defects.

4. Valves. Arrangements have been made to install the Lunkheimer valve in the 1A pump loop for performance tests.
5. E.M. Flow Meters. Arrangements have been made to calibrate the NaK and sodium flow meters against a water calibrated venturi meter in the 1A pump loop.
6. Check Valves. A static loop for testing the Atwood-Morrill check valves is now under construction.

## II ENGINEERING

### A. Unit Operation

This section of the report deals with engineering fundamentals where the information collected may be applied to the design of many engineering units.

#### 1. Heat Transfer

- a. Velocity-Temperature Profile. This work is intended to add to fundamental knowledge of heat transfer in liquid metals. A correlation of velocity and temperature profiles will permit a determination of the ratio of heat and momentum diffusivities and consequent refinements in the calculation of heat transfer coefficients.

Current work is concerned with establishing the feasibility of using an adaptation of the E.M. flow meter to determine the velocity profile of a liquid metal stream. Several profiles have been taken on NaK (56 wt. % K) in a 2-inch N.P.S. test section under isothermal conditions with a 0.018 in. diameter probe. A preliminary correlation indicates agreement to within 7% of Nikuradse's predictions. Future work will entail more experiments with the velocity probe under isothermal conditions and the construction of a cooling loop for making profile measurements under heat transfer conditions.

- b. Natural Circulation. Natural circulation with NaK (56 wt. % K) is being studied on the shell side of a vertical unbaffled 19-tube stainless steel heat exchanger (1/8 in. o.d. tubes, 12 in. long, inside a 1 in. shell). The data lie below McAdams correlation<sup>(1)</sup>.

---

<sup>(1)</sup>McAdams, W. H., "Heat Transmission", 2nd Edition, McGraw-Hill Book Co., Inc., New York, N. Y. (1942) p. 243.

of  $Nu$  vs.  $Gr-Pr$  for horizontal cylinders and agree with Eckert's formulation<sup>(2)</sup> for liquid metal natural circulation around horizontal cylinders. Plots of Stanton number against Reynolds number show no changes in the transition from thermal circulation to forced circulation: an E.M. pump was installed in the natural circulation loop for these studies.

- c. Cross Flow Exchanger. Some interest has been expressed in the behavior of liquid metals in a cross flow exchanger. Information on this subject would also be of value in predicting the performance of baffled exchangers in which cross and parallel flow are combined.

A plastic model of the proposed exchanger has been made and will be used to visually study the flow characteristics of dispersing vanes. This work is proceeding under a low priority.

- d. Single Tube Steam Generator. The single tube steam generator was originally built to test the performance of the suggested double wall tubes to be used in the 1000 KW heat transfer unit steam generator. To date three tubes have been tested and a Technical Report is being written. Several additional check runs were made during this report period on the solid wall tube. Detail information on this experiment may be obtained from the Technical report when it is issued. Due to the considerable amount of calculating and rechecking this report will not be available until May 1, 1953.

The equipment is being modified in order to make a life test of one of these tubes using the Mark B specifications (temperature, pressure, etc.). Further details on this latter experiment will be found on page 14.

- 2. Thermal Shock. The thermal shock apparatus, see next page, is used to test the ability of various reactor system components to withstand the rapid temperature changes anticipated during "scram operations". The test is made by quenching heated specimens with cold NaK. Surface temperature changes of  $550^{\circ}F$  per second have been obtained with resulting calculated transient stresses of 130,000 psi (assuming no plastic flow). The thermal shock ap-

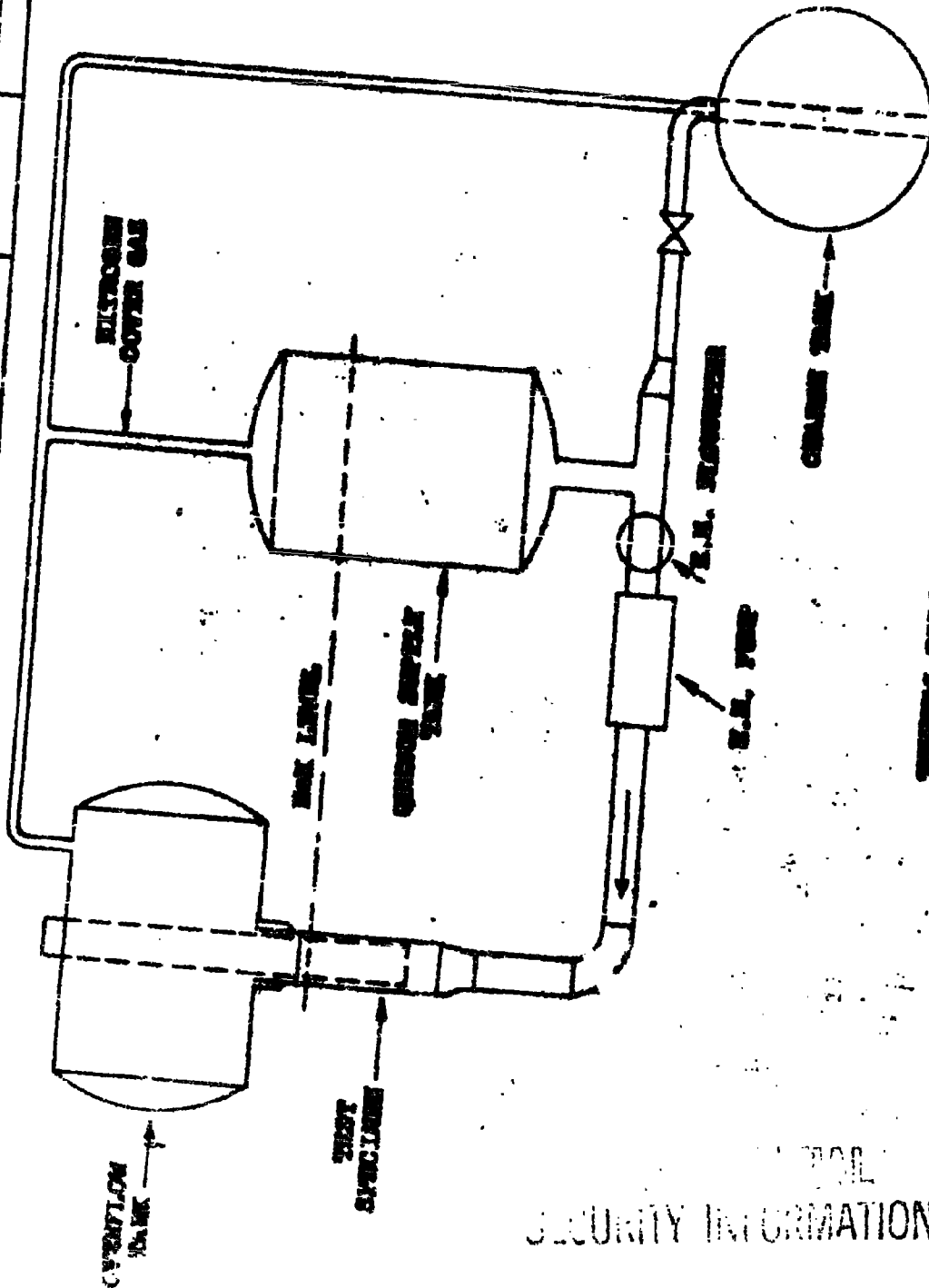
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(2) Eckert, E. R. G., "Transfer of Heat and Mass", McGraw-Hill Book Co., Inc. New York, N. Y., (1950) pp. 158-162.

Bonilla, C. F., S. C. Hyman and G. W. Erlich, Natural Convection Transfer Processes, Preprints of Paper for Heat Transfer Symposium at Forty-fourth Annual Meeting Am.Inst.Chem.Engrs. (1951). p 76 (1951).

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MINING ENGINE APPARATUS

MINE SAFETY APPLIANCE  
COMPANY

PITTSBURGH, PA., U. S. A.

FRAC TIONAL +

DECIMAL +

DO NOT SCALE  
DRAWING

SHEET

NONE

DATE 4-14-53

BY M.C.T. 4-15-53

TOOLS

APP. 4-15-53

FLOW SHEET

D - 1516 - A114

USED ON

TOOL NO.

FINISH

MATERIAL

PART NO.

REVISIONS

paratus has been idle since January 4 because of the lack of specimens. A Mark A tube sheet specimen is now being installed and will be tested during the first half of April. A tube sheet specimen from Griscom-Russell is scheduled for delivery April 21, 1953.

3. Hazard (Water-NaK reactor). Although the past work on hazards has been of a fundamental nature, the last three months were devoted to the testing of a particular geometry requested by KAPL. The purpose of the tests has been to evaluate the hazard, should leaks develop in a heat exchanger containing water and liquid metal.

Two runs have been made, during this report period, to determine the results of a reaction between NaK and water in thin annular space. The annular space was 0.0625 in. thick and 24 in. long formed by a 1 in. pipe inside a 1½ in. pipe. The equipment sat vertical with the seal between the NaK and H<sub>2</sub>O at the top of the annular space. Before the seal was broken the water was at 350°F under 400 psi nitrogen pressure and the NaK at a higher temperature under 200 psi nitrogen pressure. On breaking the seal the NaK pressure immediately rose to the water pressure; after 1½ hrs. standing, there was no change. When the water pressure was dropped 20 psi the NaK pressure followed immediately. If all of the available NaK (located only in the annular space and the ½ in. connecting pipe) were to have reacted with the water to form NaK hydroxide, the pressure on the system should have gone to approximately 1100 psi.

When the equipment was cleaned the water-NaK interface (this interface was more probably NaK hydroxide-NaK) was located in the ½ in. horizontal pipe connecting the bottom of the annulus space with the NaK expansion tank. Since all of the NaK did not react and since the maximum possible pressure was not reached, the mechanism of the reaction was probably as follows. The water, under the higher pressure, started down the annular space on the breaking of the seal. This water reacted with some of the NaK, producing both NaK hydroxide and hydrogen and at the same time forced some of the NaK back into the expansion chamber compressing the nitrogen cover gas. The pressures in both expansion chambers became equal at about the time the interface moved into the ½ in. piping. The reaction came to a standstill at this point because either hydrogen or highly concentrated NaK-hydroxide solution or both kept fresh water from contacting additional NaK. Since the hazard tests are made in the same testing area as the single tube steam generator, no plans are being made for future tests within the next three months.

## B. Development

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The information covered in this section of the report deals with the status of the development of items such as pumps, instruments, etc.

### 1. Pumps

- a. E.M. Pumps. This section describes E.M. pumps required in the operation of experimental loops on this project. In E.M. pump design and development emphasis is being placed on operation at high liquid metal temperatures and improvement in operating efficiencies.

#### 1. Construction. Four E.M. pumps have been completed during this quarter.

One 25 GPM, 30 PSI E.M. pump, Conduction type  
One 5 GPM, 20 PSI E.M. pump, Conduction type  
One 0.5 GPM, 200 PSI E.M. pump, Conduction type  
One 3 GPM, 20 PSI E.M. pump, Conduction type

The first three pumps are to be used on valve testing loops and the fourth on loop operation above 1000°F. E.M. pumps to be built in the next quarter are as follows.

Four 5 GPM, 30 PSI E.M. pumps (Conduction type) for use with the Lunkenheimer piston operated valves now on order.

One 120 GPM, 30 PSI E.M. pump (Conduction type) for full scale testing of the individual components of the 1000 KW Heat Transfer Unit which are not in use in the main loop.

Five 3 GPM, 20 PSI E.M. pumps (Conduction type) for use in connection with sludge meters on the 1000 KW Heat Transfer Unit.

- ii. Design - A.C. Conduction. The field core and coils for a 120 GPM, 30 PSI E.M. pump have been designed and are now under construction. After tests have been made on this unit the armature will be designed and construction of the pump completed. Recent investigations in E.M. conduction type pump design indicate that the efficiency of the pumps designed prior to February 1953 can be greatly increased at some sacrifice of size and weight. Redesign, construction and testing of many of the previous models will be made in the next quarter.

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111. Design - A.C. Induction. An experimental A.C. Induction type E.M. pump has been designed and constructed. Tests are now being conducted using a pumping section having a rectangular cross section with inside dimensions being 0.15 in. x 1.6 in. x 28 in. long. Several pumping sections have been fabricated and each will be used to determine the flow rate for different air gaps.

b. Mechanical Pumps - Solid Sodium Seal. The solid sodium seal program was designed to gather information for the 1000 KW heat transfer unit and to supply fundamental information. The purpose of the test is to design a seal between a rotating shaft and molten sodium by using the solid sodium as the sealing medium. The program has been divided into three sections; Fundamental, Gland Testing and Pump Testing.

i. Fundamental. A spare drill press has been converted for quick screening tests of ideas. The design of the seal housing and sodium containers has been drawn, approved and is ready for construction.

ii. Gland Testing. This section of the program was started first and has furnished the information to date. A packing gland test was set up and performance measured over relatively long times. Sodium flow past the gland was obtained by natural circulation and the temperature and pressure of the sodium at the end of the shaft was in all cases 1000°F and 12 psi respectively.

Two shaft materials have been used; one stainless steel and the other mild steel with the packing area metallized with a Chromium, Boron, Nickel alloy called Colmonoy, Metco H. The longest run, before failure, with the stainless steel shaft was 170 hours. The longest run with the metallized shaft was 1242 hours and the test failed due to the bearings rather than the packing. A report has just been completed on this phase of the program and should be ready for distribution soon.

111. Pump Testing. A standard pump was converted for use with a solid sodium seal but upon assembly a leak was discovered in a flange. The flange section has been redesigned for welding.

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The program for the next three months will include tests on all three phases of the program.

## 2. Instruments

- a. E.M. Flow Meter. The purpose of this work has been to compare the calibration of an E.M. flow meter obtained by physical constants (flux, electrical resistance, and physical dimension measurements) with actual calibrations obtained by performance tests using liquid metals at operating temperature. The report on this phase of the work is awaiting final checking of the electrical resistivity data on the various NaK alloys at high temperature before final decisions and checking.

This group also calibrates E.M. flowmeters by either of the above methods for use on loops within the project. The following were calibrated.

- i. Two 1200 gauss magnets for 1 in. pipe have been calibrated by physical constants for use on the life test of the double wall tube loop (Section II-C-4).
- ii. A flow meter to be used on the NaK cooling stream of the Homopolar Generator was calibrated by the physical constants method.

Special search coils for the E.M. flow meters on the 1000 KW unit have been completed and a thorough measurement of the flux pattern of the 1000 KW unit flow meter magnets is now in progress. These measurements will be completed during the next quarter.

- b. Sludge Meter. An approach to a sludge meter is being studied with a design in which one side of a  $\frac{1}{8}$  in. o.d. tubing by-pass will be cooled until the oxide begins to deposit on the cold wall. Deposition should be indicated by a drop in the overall heat transfer coefficient, a change in the flow meter readings at the entrance and exit of the by-pass section or a change in the  $\Delta T$  across either the by-pass or the cooling section.

Several successful runs have been performed at an oxygen concentration  $>0.010$  wt. %. Experimentation will continue to determine the feasibility of this device for use as a sludge meter at lower oxygen levels.

- c. High Temperature Pressure Element. The high temperature pressure element was designed primarily for use

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with high temperature sodium. The pressure is transmitted by a rod in a cooled zone from a diaphragm in contact with the sodium to a second diaphragm where the stress is measured by a strain gage. The purpose of the cooling of the rod is two-fold in that it eliminated temperature effect at the second diaphragm and also acts as a frozen seal should the first diaphragm rupture. A report on the high temperature pressure element has been written and after slight revision will be distributed.

The plans for the next three months call for improvements in the design so that the gage can be calibrated during operation. Improved design strain gages will also be tested.

3. Valves - Piston Operated. The Westinghouse-Crane piston operated valve test was set up as a test for the 1000 KW heat transfer system. The valve is normally closed by a spring and is opened by pressure acting on a piston. A test on this valve to temperatures of 650°F was reported last November in Memorandum Report 24.

Since the last report an E.M. pump has been built to develop the operating pressure of 200 psi. The use of this pump will replace the method of using nitrogen pressure which was considered a hazard when high temperatures were involved. This pump will soon be installed and the test continued.

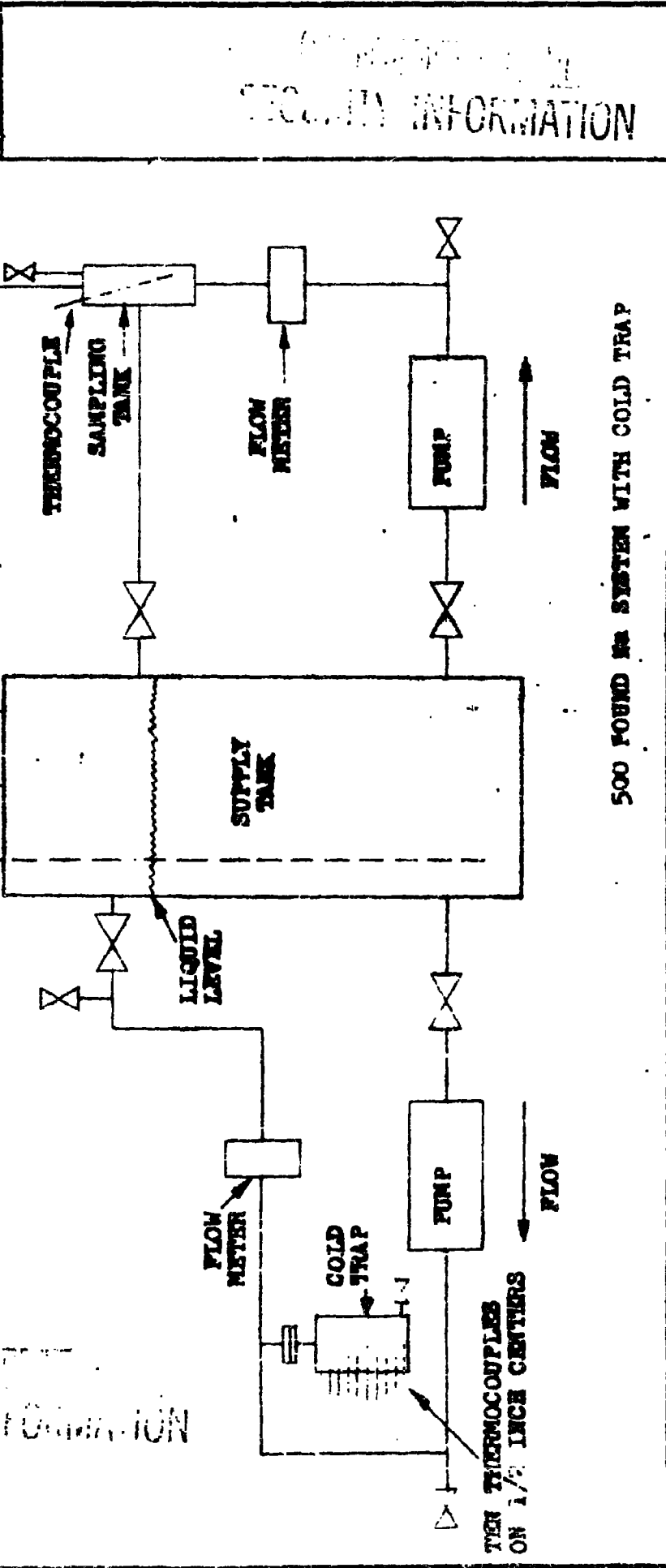
4. Cold Trap - 500 Pound System. This system, see next page, contains a 500 pound supply tank from which sodium is pumped through  $\frac{1}{2}$  inch pipe past a diffusional cold trap, the bottom of which is water cooled, and then back into the supply tank. The purpose is to test a diffusional cold trap in lowering the oxygen concentration of a fairly large system from some value over 0.010% to as low a value as possible. The results from such tests would aid in the designing of a diffusional cold trap of a size suitable for SIR.

Two tests have been run and a third test is in progress. The first two tests were unsuccessful inasmuch as the final oxygen concentrations were approximately 0.010% and 0.008% respectively. During the first test run (7 days) it is believed that the connecting pipe between the cold trap and the main loop became plugged. A better heating element was placed on this pipe for the second test (20 days) but did not improve the performance.

At the end of the second test, the loop was drained and the cold trap washed out.

MATERIAL	FINISH	TOOL NO.	USED ON
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PART NO.	REVISIONS
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500 POUND IN SYSTEM WITH COLD TRAP

MINE SAFETY APPLIANCES COMPANY PITTSBURGH, PA., U. S. A.		TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONAL + DECIMAL +		DO NOT SCALE DRAWING		SCALE NONE	
DESIGNED BY P. J. HAUGHEY		CHECKED BY P. J. HAUGHEY		APPROVED BY P. J. HAUGHEY		DATE 4-14-53	
DRAWN BY P. J. HAUGHEY		SCALE NONE		FLOW SHEET		D - 1515 - A114	

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The third test has been running for 38 days. The initial oxygen concentration was approximately 0.013%. The last seven samples have shown an average concentration of 0.008%. The cold trap temperature is approximately 200°F at its bottom and the main loop is 800°F. Some doubt has been expressed as to the reliability of these results since the oxygen sample may not be representative of the pot because the agitation loop was not working and a foreign material was found floating on the surface of the sodium. The agitation loop is being repaired with the addition of a sampling tank and further tests have been scheduled.

5. Salcomine - Oxygen Controlled Atmosphere. Enough engineering data has been taken to permit the design of a small compact unit to maintain the oxygen content of the atmosphere in a specified chamber as low as 5%. These tests have been completed and a first draft of the report has been made.

Based on the optimum operating conditions of the 100 psi and 2 cfm obtained from these tests, a new Salcomine unit was designed to meet the following conditions submitted by KAPL.

1. Maintain a 5% oxygen atmosphere with 0.1 cfm air leakage to chamber.

11. 60 - 90 day life on Salcomine.

This unit is rectangular in shape, 15-5/8 in. x 11 in. x 8-5/8 in. and capable of holding 10 lbs. of salcomine packed on the shell side, with water flowing through the tubes for temperature control of the bed.

The assembly drawing of the unit was completed and the unit is being fabricated by the Griscom-Russell Co. A suitable piping design has also been completed for the allotted space of 2 ft. x 2 ft. x 4 ft.

The new Salcomine unit will be tested along with the competitive Baker unit supplied by KAPL. Conditions of the test will approximate Mark A conditions as nearly as possible. The present firefighting chamber (volume 4000 cu.ft.) will be used and fitted with a metered "leak". Data will include the time to reduce the oxygen from 7% to 5% and the effect of humidity. Any additional tests required can be determined in the future.

**C. Operational**

The information to be found in this section deals with the life testing and the performance testing of equipment, insulation, etc.

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1. Insulation. On October 18, 1952 the SIR Mark A insulation was chosen. At this time it was decided to make a few additional tests on the insulation as supplied by Johns-Manville for Mark A. Materials for these tests are not yet available, but plans are being made to run the following six tests to check the reaction between 850°F sodium and the thermal insulation.

Test	Leak Size Diameter In.	Compartment Atmosphere % O <sub>2</sub> (bal. N <sub>2</sub> )
1	1/16	20
2	1/16	5
3	1/32	5
4	1/32	5
5	1/64	5
6	1/64	5

2. Operation Above 1000°F. An effort is being made to develop an E.M. pump to operate at 1500°F so that pumps of this type may be used to test other components at this high temperature.

Previous failures to develop such a pump were due to failure of the bus bars to adhere to the pumping section at elevated temperatures. However, this problem has been solved by Microbrazing solid nickel bus bars to the stainless steel pumping sections. After 400 hours of operation at 1500°F, of which the last 300 hours were continuous, two electrical immersion heaters failed but the pump performance did not change and mechanically it appears as sound as initially. The loop will be modified so it can be heated externally and will be operated continuously at this elevated temperature for a period of from 30 to 60 days. After the pump has proven its operational ability, other components can be tested at these high temperatures, i.e., valves, heat exchangers, etc.

3. Life Test - Thick Wall. This loop was shut down and drained last fall after 4½ years operation as a natural circulation heat transfer system. Low priority has prevented dismantling the system. It is planned to cut out the piping under an inert atmosphere and examine the pipe sections for evidence of either corrosion or deposits. Any deposits will

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be removed and analyzed chemically. Sections of the piping will later be examined metallurgically.

4. Life Test - Steam Generator. The equipment used for the single tube steam experiments is being modified into a life test of a two tube steam generator for KAPL to prove the tube design.

Figure 1 shows a flow sheet for the life test. The only change in the primary loop is the steam generator and the addition of a heat exchanger in the NaK stream at the point where the NaK leaves the furnace. The secondary loop is the steam generator NaK inlet temperature control. The temperature required at thermocouple 4 on the primary loop will control the flow from Pump 2. The NaK-air cooler will operate at full load at all times.

The life test consists of a number of temperature shocks of the following pattern.

- a. The temperature of the NaK entering the steam generator at normal conditions will be 820°F. At fifteen minute intervals the temperature will be changed over a 30 second time period from 820°F to 700°F where it will be held for 14½ minutes, then back to 820°F and held for 14½ minutes for a total of 1000 cycles. These conditions will be controlled automatically by the use of the secondary loop. During the temperature change period the NaK flow rate will vary with temperature from 100 to 20% flow. At the end of every 5 cycles heat transfer data will be taken.
- b. After 200 cycles have been completed at condition "a", condition "b" will be interposed at regular intervals for a total of 20 shocks. This test calls for changing the initial NaK inlet temperature from 850°F to 650°F in 2 seconds. This will be accomplished also with the use of the secondary NaK system.
- c. Four times during the 1000 cycles required by condition "a" the inlet NaK temperature will be changed from 850°F to 1400°F over a period of five minutes. The change will be accomplished by dropping the flow rate in the primary NaK loop.
- d. Four times during the 1000 cycles program the inlet NaK temperature will be changed from 850°F to 1080°F over a period of 60 seconds. This change will be accomplished by dropping the flow rate in the primary loop.



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- e. Four times during the 1000 cycles the inlet NaK temperature will be changed from 800°F to 1400°F over a period of 60 seconds. This change will also be accomplished by dropping the flow rate of the primary loop.

The conditions set in sections b, c, d and e will be held for a period of 15 minutes and returned to normal over the same time interval that produced the original change at which time heat transfer data will be taken.

The steam generator and the NaK to air cooler are scheduled for delivery by April 10, 1953. All other major items have been received and installed. Operation will commence as soon as the steam generator can be leak tested and installed, allowing three or four days to adjust the controls.

### III CHEMISTRY

#### A. Impurities

Since the presence of iron in the sodium in stainless steel systems may be undesirable, the behavior of iron in sodium is being investigated as a function of oxygen content, sodium temperatures and cold trap temperature.

1. Nickel Cold Trap on Stainless Steel System. Iron had always been present in relatively large amounts in stainless steel cold trap residues, but it is possible some of the iron was the result of oxygen accelerated corrosion in the cold trap. To determine the extent of iron migration from a stainless steel loop to a cold trap, a nickel cold trap was put on a stainless steel system where the oxygen content of the sodium in the system was 0.005 wt. %. The loop is being operated at 1000°F with no oxygen additions, the cold trap holding the oxygen level at 0.002 to 0.003 wt. %. Analysis of the cold trap contents will indicate the magnitude of iron transfer at low oxygen levels with the assurance that, any iron will have come from the stainless steel loop.
2. Static Nickel Pots with Cold Legs. The behavior of iron in sodium is also being studied in static nickel pots having  $\frac{1}{2}$  in. NPS cold traps 10 in. long. Iron and oxygen concentrations are followed as a function of the cold leg temperature.

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Data collected thus far are presented below.

Pot #1				Pot #2			
Wt.% O <sub>2</sub>	ppm Fe	Temp. °F		Wt.% O <sub>2</sub>	ppm Fe	Temp. °F	
		Cold Leg	Pot			Cold Leg	Pot
0.022	19	830	930	0.912	10	765	980
		Cooled cold leg for 24 hours.					
0.003	10	200	920	0.003	10	250	1050
		Reheated cold leg					
0.014	13	875	965	0.007	8	840	1010
		Cooled cold leg					
0.003	8	185	760	0.003	7	220	815
		Reheated cold leg					
0.007	9	865	920	0.005	7	810	955

Aside from the first cycle there was no return of iron to the pot and less return of oxygen each time the cold leg was reheated. No iron had been added to the pots, the only source of iron being that which was in the charged sodium.

Based on these results it may be concluded that (1) iron is initially removed by a cold trap but iron will not cold trap to values below approximately 7 ppm when the oxygen content of the sodium is low and (2) cold trapped iron and oxygen will not return completely to the main body of sodium.

Future work will entail the determination of iron concentration in sodium under controlled oxygen conditions, both in a pumped nickel loop (loop E) and in the static nickel pots.

3. Iron Solubility in Sodium. The stainless loop with a nickel cold trap (described in part 1. of this section) has been running at an oxygen level of 0.002 to 0.003 wt. % for two months, an ideal situation for the determination of iron solubility at low oxide content. The loop temperature was dropped from 1000° to 400°F in 200° steps and iron samples taken after 24 hours at each temperature; the data appears on the next page.

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Temperature of Loop °F	ppm Fe	Cold Trap Temperature °F
1000	13	190
820	9	170
605	8	165
300	6	170

**B. Accessibility**

- 1. Mass Transfer.** The migration of stainless steel components through sodium is of concern for access to Mark A and B components. Radioactive sources of 347 stainless steel have been immersed in flowing sodium at 800°F both with and without a 230°F  $\Delta T$  around the loop. The velocity of the sodium varied from 0.2 to 2 ft/sec. and the oxygen content was 0.007 wt. %.

Using a source which was six months old, the contamination around the loop initially rose to 20 cpm above background, with 100 cpm (G.M. tube uncorrected for geometry) at the sample site. Further immersion produced no additional contamination, nor was there any significant localization of contamination.

Under conditions as described above, with a three month old sample the count rate rose to 140 cpm around the loop, the rise occurring within 24 hours after immersion. There was no further contamination. When received this sample was covered with sodium and contaminated with fission products. The sodium and fission products were removed as completely as possible with alcohol, water and acid washes, but it is conceivable some fission products were absorbed into the stainless sample. Sodium samples taken from the loop showed high  $\beta$  activity.

A stainless steel strip (type 347) is being irradiated at BNL and should be available within two months. Experiments are planned to investigate the effect of oxygen on mass transfer. An attempt will be made to determine more accurately the extent of mass transfer and a cold trap will also be used to investigate localization of contaminants.

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2. Mark A Model. NSA was asked by KAPL to consider the feasibility of building a model of Mark A heat exchange system to 1/1000th scale in conjunction with KAPL's considerations of the same experiment. The model was to be used for mass transfer experiments, under Mark A conditions and especially under the same geometric ratios as exists between Mark A components. After consideration of the data furnished by KAPL it appeared that construction and operation of the Model would not completely satisfy all the requirements and therefore the data collected would be incomplete. It was recommended that separate experiments, evaluating all the factors to be considered in the Mark A model, would furnish information which would also be applicable to future systems as well as to Mark A.

C. Corrosion

1. 1500°F Unstressed Corrosion. Various metals have been exposed to NaK at 1500°F for 500 hours with oxygen samples being taken before and after each test. These tests were run in conjunction with the 1000 KW unit and basic research.

An inconel specimen, after being tested, showed a 3% weight gain and was found to be magnetic. The stainless steel specimen holder (1/16 in. rod) had also become corroded and magnetic. The O<sub>2</sub> content varied from 0.028 to 0.107%.

Another inconel specimen was tested under similar conditions except that the apparatus for this test contained a cold trap which was used to maintain the oxygen content at approximately 0.004%. The results of this test showed that the specimen had a 0.02% weight loss with no sign of being magnetic.

At the present time a test is being run on a specimen consisting of two different types of metals threaded together. The metals are stellite 6 and type 316 stainless steel. This specimen will be tested for galling after exposure to NaK at 1000°F for 500 hours. The test will be completed April 1.

A report is being written on the results of all specimens tested to date.

2. Electrical Insulation Corrosion. Various materials suitable for electrical insulation have been exposed to NaK at temperatures of 250 and 300°F. These tests have varied in length from 2 weeks to 6 months. These tests were run in order to aid in the design and operation of the homopolar generator for the 1000 KW unit. The six month and three month tests on nylon rod, molded nylon, Butyl and Buna S are completed. The results of these tests will be reported in a memorandum report. It is believed that these last two tests finish the Electrical Insulation Corrosion program.

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**IV**  
**VISITS AND CONFERENCES**

No.	Date	Subject	Location	Parties Involved
1.	1-5-53	Accessibility	NRL, Washington, D.C.	NRL, G-E and MSA
2.	1-9-53	Life Test of Duplex Tube	MSA, Callery, Pa.	G-R, NRB and MSA
3.	1-14-53	Liquid Metal Technology	MSA, Callery, Pa.	Detroit-Edison, ONR-Pittsburgh and MSA
4.	1-21-53	Oxygen Content Controlled Atmosphere	MSA, Callery, Pa.	G-E and MSA
5.	1-27-53	Heat transfer Components	MSA, Callery, Pa.	G-R, G-E and MSA
6.	1-29-53	Hazard Testing H <sub>2</sub> O-NaK Reaction	G-R, Massillon, Ohio	G-R, G-E and MSA
7.	1-29-53 1-30-53	Liquid Metal Technology	G-E, Schenectady New York	G-E and MSA
8.	2-5-53 2-6-53	Heat Transfer Components	MSA, Callery, Pa.	California Research & Development and MSA
9.	2-6-53	Inspection	MSA, Callery, Pa.	NRB and MSA
10.	2-19-53	Heat Transfer Components	MSA, Callery, Pa.	Commonwealth-Edison, Chicago, AEC, Chicago and MSA
11.	2-20-53	MSA Program	MSA, Callery, Pa.	NRB and MSA
12.	2-26-53	E.M. Pump and Homopolar Generator	Westinghouse, Pittsburgh, Pa.	Westinghouse and MSA
13.	3-3-53	Heat Transfer Component	MSA, Callery, Pa.	ANL and MSA
14.	3-4-53	Welding	MSA, Callery, Pa.	BuShips and MSA
15.	3-6-53	Steam Generator	MSA, Callery, Pa.	G-R and MSA
16.	3-13-53	Inspection	MSA, Callery, Pa.	ONR-Pittsburgh and MSA

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**Visits and Conferences - continued**

- |     |         |                                   |  |
|-----|---------|-----------------------------------|--|
| 17. | 3-17-53 | Inspection                        | MSA, Callery, Pa. NRB and MSA                            |
| 18. | 3-18-53 | Steam System                      | NRB, Washington, D.C. NRB, G-R, G-E, BuShips and MSA     |
| 19. | 3-23-53 | E.M. Pump and Homopolar Generator | Westinghouse, Pittsburgh, Pa. Westinghouse and MSA       |
| 20. | 3-27-53 | Review                            | MSA, Callery, Pa. ONR-New York<br>ONR-Pittsburgh and MSA |
| 21. | 3-27-53 | Steam Generator                   | MSA, Callery, Pa. G-R and MSA                            |

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**V**  
**REPORTS ISSUED**  
**on**  
**Contract N9onr-85801**

<b>Date</b>	<b>Type</b>	<b>Title</b>	<b>Author</b>
1-20-53	Status Report No. 15	Status Report 15 for October, November and December, 1952	R. C. Werner, et.al.
2-27-53	Memorandum Report No. 26	Preliminary Report 4 on Thermal Shock Apparatus	M. M. Shrut R. A. Tidball
2-27-53	Memorandum Report No. 27	Feasibility of Model Operation for Mass Transfer Experiments	J. W. Mausteller M. J. McGoff
3-3-53	Interim Report * No. 1	Interim Report January 1 to February 15, 1953	R. C. Werner, et.al.
3-9-53	Technical Report No. 21	Removal of Na <sub>2</sub> O from a NaK System Using a Natural Circulation Cold Trap	E. F. Batutis S. L. Walters J. W. Mausteller
3-11-53	Memorandum Report No. 28	Preliminary Report 3 on Analytical Loop D	R. C. Andrews E. C. King
3-12-53	Memorandum Report No. 29	The Application of Cold Traps to the Accessibility Problem	J. W. Mausteller

\* Previously called Monthly Report; now issued between Status Reports.

# SECURITY INFORMATION

## VI DISTRIBUTION OF PERSONNEL

### I 1000 KW HEAT TRANSFER UNIT

- A. Design - R. A. Tidball, F. L. Mangold, M. M. Shrut,  
D. R. Bosley(1) and S. N. Tower(2)
- B. Engineering - J. M. Lewis, P. J. Haughey and J. K. Richter
- C. Procurement - J. M. Lewis, V. J. Reed and J. K. Richter
- D. Construction - J. M. Lewis, F. G. Mann and J. K. Richter
- E. Testing - R. A. Tidball, M. M. Shrut, F. L. Mangold and  
D. R. Bosley(1)

### II ENGINEERING

- A. Velocity-Temperature Profile - J. W. Mausteller and  
R. H. Rahiser
- B. Natural Circulation - J. W. Mausteller and M. J. McGoff
- C. Cross Flow Exchanger - J. W. Mausteller and J. N.  
Gordon(3)
- D. Single Tube Steam - E. C. King and R. C. Andrews
- E. Thermal Shock - R. A. Tidball and M. M. Shrut
- F. Hazards (Water-NaK Reaction) - E. C. King and R. C.  
Andrews
- G. E.M. Pumps - M. E. Wahl
  - 1. Construction - G. E. Meeker, Jr.
  - 2. Design - A.C. Conduction - M. E. Wahl and G. E.  
Meeker, Jr.
  - 3. Design - A.C. Induction - R. E. Baker

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(1) On loan from Grison-Russell Company

(2) On loan from Westinghouse Company

(3) On loan from Blaw-Knox Division

• Distribution of Personnel - continued

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- H. Mechanical Pumps - Solid Sodium Seal - E. C. King and  
V. K. Heckel
- I. E.M. Flow Meter - M. H. Wahl and J. R. Taylor
- J. Sludge Meter - J. W. Mausteller and J. N. Gordon
- K. High Temperature Pressure Element - E. C. King and  
V. K. Heckel
- L. Valves - Piston Operated - E. C. King
- M. Cold Trap - 500 Pound System - E. C. King and R. C.  
Andrews
- N. Selcomino - Oxygen Control Atmosphere - E. C. King and  
W. Milich
- O. Insulation - R. A. Tidball
- P. Operation Above 1000°F - M. H. Wahl and G. E. Meeks
- Q. Life Test - Thick Wall - R. A. Tidball
- R. Life Test - Steam Generator - E. C. King and R. C.  
Andrews

III CHEMISTRY

- A. Nickel Cold Trap on Stainless Steel System - J. W.  
Mausteller and S. J. Rodgers
- B. Static Nickel Pots With Cold Legs - J. W. Mausteller and  
S. J. Rodgers
- C. Iron Solubility in Sodium - J. W. Mausteller and S. J.  
Rodgers
- D. Mass Transfer - J. W. Mausteller, E. F. Batutis and  
J. N. Gordon
- E. Mark A. Model - J. W. Mausteller, M. J. McGoff and  
J. N. Gordon
- F. 1500°F Unstress Corrosion - E. C. King and R. C. Andrews
- G. Electrical Insulation Corrosion - E. C. King and R. C.  
Andrews

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